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TECHNICAL
PUBLICATION

NATIONAL PHOTOGRAPHIC
INTERPRETATION CENTER

TEST AND EVALUATION REPORT

[redacted] 7X FILAR EYEPIECE SET FOR THE ZOOM [redacted] STEREOSCOPE SYSTEM

25X1

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NPIC/R-51/71
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TECHNICAL PUBLICATION

TEST AND EVALUATION REPORT

25X1 [redacted] 7X FILAR EYEPIECE

25X1 SET FOR THE ZOOM [redacted] STEREOSCOPE SYSTEM

25X1 [redacted]

Test and Evaluation Branch
Engineering Support Division
Technical Services Group

NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER

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ABSTRACT

The Filar Eyepiece set, designed and fabricated [redacted] 25X1
25X1 [redacted] was tested according to NPIC contractual requirements and for usefulness to NPIC. The Filar eyepiece is of good optical design and construction. However, it will not be useful to NPIC until the mechanical interfacing problem with the [redacted] Zoom [redacted] Stereoscope is 25X1
solved. This stereoscope has both eyepiece focusing rings and image rotation rings on the eyepiece tubes. The Filar 25X1
Eyepiece holding mechanism is designed to bridge these movable rings to a stable portion of the eyepiece tubes to prevent rotation of the Filar Eyepiece. Both IEG and TEB found the mechanism to be inadequate.

The Filar Eyepiece satisfied sixteen of the other twenty contractual requirements. The other deficiencies are not very serious.

Both IEG and IAS evaluated the Filar Eyepiece and made generally favorable comments about the optical characteristics.

1. INTRODUCTION

1.1 Background

The 7X Filar Eyepiece set (Fig. 1) was developed by [redacted] for use on Zoom [redacted] and modified Zoom [redacted] Stereoscope systems. It provides the PI with the capability of obtaining measurements on roll film as a part of routine photo interpretation. Contract monitoring was performed by TSG/RED for IEG.

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Because of the length of the Filar Eyepieces, the Zoom [redacted] system must be modified with certain internal design changes. The testing reported here was done only with the modified versions.

Final delivery of the eyepiece set was made on 24 February 1971. A memorandum test report (TSG/ESD/TEB-084/71) was issued in April 1971, stating that the eyepieces generally meet the contract requirements except for an apparent yellow color seen through them and for certain potentially serious mechanical problems.

The IEG and IAS operational evaluations were completed in October and August of 1971. Their comments are included in Section 5.2.

1.2 Test Objectives

Test plan objectives accomplished include: 1) testing per twenty-one contractual requirements, 2) operational evaluation by two components, and 3) minor engineering evaluation testing.

2. SUMMARY OF TEST RESULTS

2.1 General

The Filar Eyepiece (Figure 1) is a microscope eyepiece, fitted with a reticle and a movable cross-hair (Figure 2) which may be adjusted with a calibrated dial. The set consists of the Filar eyepiece itself and a companion eyepiece of similar optical characteristics but without the measurement capabilities.

Testing of this instrument was performed in three phases: (1) acceptance testing against contractual requirements, (2) operational evaluation by experienced PI's, and (3) engineering evaluation to ascertain certain characteristics not given in the specifications.

25X1 Overall the [redacted] Filar Eyepiece is of good optical design and construction, subject to correction of certain mechanical problems.

2.2 Acceptance Tests

The eyepieces satisfy sixteen of twenty-one contractual requirements. Of the five deficiencies found in the acceptance testing only one was commented on in the operational testing. The comment was that the holding mechanism which should restrain the Filar Eyepiece from rotating sometimes slips. The remaining deficiencies were:

- The eyepieces impart a yellowish tinge to the image.
- Certain parts requiring non-reflective coatings are not blackened.
- Greenish and yellowish rings may be observed within the eyepieces, suggesting improper anti-reflection coating.
- The operating manual omits needed cautions and is not up-to-date in some respects.

The design objectives and specifications that were met include field-of-view, optical magnification, reticle layout, optical resolution (both on- and off-axis), optical aberrations, filar motion, eye relief, interpupillary settings,

parfocality (zoom), mechanical (not optical) construction, compatibility with Zoom [redacted] Stereoscopes, optical schematic, and manufacturing drawings. 25X1

2.3 Operational Evaluation

IEG found the Filar Eyepiece set suitable for operational use subject to the following revisions: (1) change the reticle by lengthening the cross line of the crosshairs and (2) revise the holding mechanism to lock the eyepiece firmly in place during measurements.

They singled out the following features for favorable comment:

- o No distracting color.
- o Negligible distortion.
- o Flatness of the field-of-view.
- o Wideness of the field-of-view.
- o Optical magnification (7X).
- o Torque adjustment on micrometer shaft.
- o Location (transverse) of the fixed scale.

2.4 Engineering Analysis and Evaluation

Possible damage to Zoom [redacted] internal parts can still occur with modified Zoom [redacted] whenever the left (but not the right) eyepiece focusing adjustment is left all the way down and the Filar Eyepieces are inserted hurriedly. No interference occurs in the normal focus range of the instrument. 25X1 25X1

To make reasonably accurate measurements the PI must achieve optimum adjustment of the Filar eyepiece holding mechanism spring, place very little non-useful pressure on the micrometer drum, and avoid changing the interpupillary distance adjustment during a measurement.

The Filar Eyepiece has to be mounted on a Zoom [redacted] which has two separate adjustment features (focus and image rotation) on each eyepiece tube. The holding mechanism must therefore bridge two movable parts to a stable part of the eyepiece tube. The resulting mechanical interface problems (see Sections 5.3.2 and 5.3.5) are potentially serious. A mechanical engineer who examined it has doubts about the suitability and ruggedness of the prototype's holding mechanism feature. 25X

3. CONCLUSIONS

25X1 The [redacted] 7X Filar Eyepiece is of good optical design and construction. Its mechanical interfacing with
25X1 the Zoom [redacted] is not acceptable to NPIC for procurement without modification.

4. DESCRIPTION OF EQUIPMENT

The 7X Filar Eyepiece set consists of two eyepieces in a roughly cubical storage case (6 x 6 x 7"). The measuring eyepiece fits into the left or right eyepiece tubes of Zoom [redacted] Stereoscope Systems with one exception. The exception is the early (unmodified) Zoom [redacted] with image rotation [redacted]

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The measuring (Filar) eyepiece has a flat steel spring which extends past the image rotation ring to the body of the eyepiece tube. A knurled thumbscrew holds the spring and rubber pad against the tube body to prevent rotation of the filar during a measurement.

Visible through the measuring eyepiece is a fixed reticle scale and a movable crosshair (Fig. 2). A micrometer drum both moves the crosshair across the field-of-view and provides the measurement of the movement. This eyepiece has a focus adjustment to accommodate different observers. The companion eyepiece services to provide the same magnification and eye-point to the other eye since the 7X eyepieces are not compatible with the eyepieces usually used on Zoom [redacted]

25X

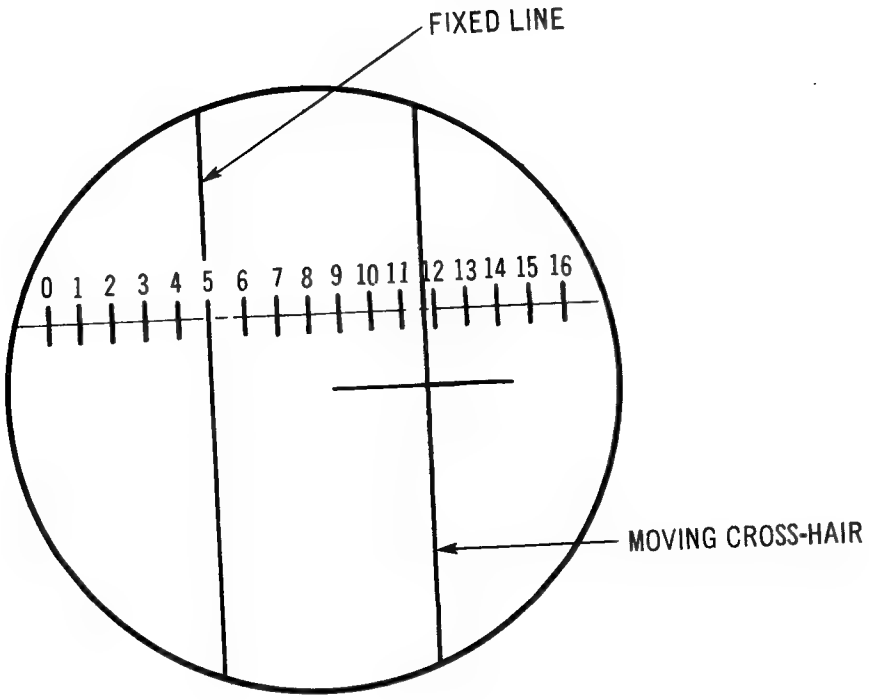

Figure 2. Filar Eyepiece Reticle

5. TEST DETAILS

5.1 Acceptance Tests

ITEM	DESIGN OBJECTIVES - SPECIFICATIONS	TEST METHOD	RESULTS - CONCLUSION
5.1.1 Field-of-View (mm)	> 138/(magnification) Zoom Setting 0.7X 1.5X 3.0X Requirement 28.2 13.1 6.6 (mm)	Record the visible range on a stage micrometer at three equiangular directions across the field-of-view.	Zoom Setting 0.7X 1.5X 3.0X Meas. (min.) 28.9 13.6 6.6 Satisfies requirement.
5.1.2 Eyepiece Magnification (linear)	7X	Visually superimpose a scale placed on the light table (viewed with one eye looking through the Zoom [redacted] and an illuminated, calibrated circle (viewed at unity magnification through a prism arrangement with the other eye). Note how many scale divisions are included within the calibrated circle.	7X Satisfies requirement.
5.1.3 Reticle Layout	RED furnished a drawing for the reticle (Figure 2).	Visual comparison between the drawing and the reticle.	They appear to be identical. Meets requirement.
5.1.4 Optical Resolution (On-axis and off-axis)	Maintain the optical quality of the same instrument when used with [redacted] 10X Wide Field Eyepieces.	Focus at maximum zoom magnification in the center of the field-of-view. Without refocusing position the Zoom [redacted] (at minimum zoom magnification) so that the resolution target is in the appropriate part of the field-of-view and read the sagittal (radial) and tangential resolution values. Divide the resulting values in line pairs/mm by the appropriate magnifications (7X for the 10X eyepiece and 4.9X for the 7X	The Filar Eyepiece met this requirement. The Filar Compensating Eyepiece was 20% low in one out of ten measurements. The least increment of this measurement due to the discrete (or step) nature of resolution targets is about 10%.

Acceptance Tests (continued)

ITEM	DESIGN OBJECTIVES - SPECIFICATIONS	TEST METHOD	RESULTS - CONCLUSION
5.1.4 (continued)		eyepiece at a 0.7X zoom setting). Record the median value of three observers after computing the percentage increase in resolution per magnifying power given by the filar eyepieces over the [redacted] 10X Wide Field eyepiece.	It essentially meets this requirement.
5.1.5 Apparent Color	Maintain the optical quality of the same instrument when used with [redacted] Wide Field Eyepieces.	Subjective comparison by two test engineers.	They agree that the filar eyepiece is definitely yellower. Does not meet the requirement.
5.1.6 Anti-reflection Coating	All refractive elements shall be coated for maximum light transmission.	Visual examination for anti-reflection coatings.	A blue cast is observable at both ends of the eyepiece when turned in the light like a diamond. However, distinct rings are visible in the blue cast and three distinct sets of greenish and yellowish rings are visible when looking through the filar eyepiece. It may not meet the requirement.
5.1.7 Astigmatism (on-axis)	Maintain the optical quality of the same instrument when used with [redacted] Wide Field Eyepieces.	Look for any set of orthogonal lines which require refocusing to obtain sharp focus from one line to the other.	No significant on-axis astigmatism was observed. Meets requirement.
5.1.8 Distortion	Same as above.	Use the filar measuring capability to determine the amount of pincushion or barrel distortion that is present.	None was detected. Meets requirement.

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Acceptance Tests (continued)

ITEM	DESIGN OBJECTIVES SPECIFICATIONS	TEST METHOD	RESULTS - CONCLUSION
5.1.9 Congruence (Object-Image)	Image shall not be rotated, inverted, or reverted with respect to the object.	Check	Meets requirement.
5.1.10 Filar Motion	Shall be constructed in a manner that is physically similar to the existing 15X [redacted] Filar. One revolution of the micrometer drum shall advance the filar crosshair 1mm in the eyepiece focal plane. The drum shall be divided into 100 equal increments. Parallax between the moving crosshair and the fixed reticle shall be a minimum.	Check	Meets requirement.
5.1.11 Eye Relief	At least 20mm.	Measure the movement required to take a ground glass screen from contact with the eyepiece to that height where the smallest and sharpest exit pupil shows on the screen.	It ranged from 18.5 to 21.0mm for extreme zoom and IPD settings. The arithmetic average of 26 readings is 19.7mm. Essentially meets requirement.
5.1.12 Exit Pupil	The companion (compensating) eyepiece shall project an exit pupil of the same object from the second optical path of the Zoom [redacted] to the same plane as that of the filar eyepiece.	Focus both eyepieces. Use a ground glass screen to make the exit pupils visible. Measure the mismatch in height from the object plane.	About 1mm. Essentially meets requirement.
5.1.13 Interpupillary Distance	Minimum of 60mm with the measuring scale along the 'X' or 'Y' axis. At about 30° it should be 66.5mm.	Suspend a ground glass screen over the eyepieces so that small sharp exit pupils are made visible. Measure the distance between the centers of the exit pupils.	Except for the maximum focal setting (the highest physical position) the readings were 60mm for the 'X' position and 59.6mm for 'Y', and 65.5mm for the -30° orientation. The maximum distances were all well over 80mm. Essentially meets requirement.

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Acceptance Tests (continued)

ITEM		DESIGN OBJECTIVES SPECIFICATIONS	TEST METHOD	RESULTS - CONCLUSION
5.1.14	Constancy of Focus	Both the object image and the reticle/scale shall remain in sharp focus throughout the Zoom [redacted] zoom range.	Measure the refocusing required to maintain sharp focus as the zoom setting is varied.	Except for eyepiece focus settings of about ± 3 diopters no refocusing was required when zooming from 3.0X down to 0.7X. Essentially satisfies this requirement.
5.1.15	Mechanical Construction	All surfaces shall be of a corrosion-resistant type or shall be suitably treated for protection against corrosion. All hardware shall be of American Standard sizes, with a minimum of types of sizes used, and shall be corrosion-resistant. Wherever possible, sealed bearings of the prelubricated type shall be used. All sharp edges and corners shall be rounded so as to prevent any injury to personnel. Structural rigidity of the device shall be sufficient to withstand repeated jarring.	Conduct an external inspection and examine the drawings.	The drawings call for anodizing or other treatment for all metallic surfaces. The visible hardware is either stainless steel, chrome-plated, or painted. The micrometer screw (internal) is cold finished, C12L14, steel. 12L14 is not a stainless steel, yet no finish is specified. However, for our office type environment it is considered that there is no real corrosion hazard. The remainder of this requirement is met. Essentially meets requirement.

Acceptance Tests (continued)

ITEM		DESIGN OBJECTIVES SPECIFICATIONS (REQUIREMENTS)	TEST METHOD	RESULTS - CONCLUSION
5.1.16	Optical Construction	All non-reflecting and non-transmitting internal surfaces shall be coated with non-reflecting black material. Optical elements shall be mounted with sufficient rigidity to maintain alignment and withstand repeated jarring.	Conduct an external inspection and examine the drawings.	While most of the internal surfaces requiring black coatings are so coated, not all of them are. The remainder of this requirement is met. Does not meet requirement.
5.1.17	Physical Configuration	Must be as compact as possible. A lock will be provided to prevent rotation of the filar about the optical axis of the Zoom [redacted]	Measure the maximum external dimensions along the micrometer drum axis and from the Zoom [redacted] mating shoulder (or seat). Check the lock.	The micrometer drum axis dimension is 4 1/32". The maximum height is 3 1/32". The lock was provided (see paragraphs 5.3.5 and 5.3.6 for engineering evaluation). In less than 9 months of intermittent use the locking spring (flat, type 301, stainless steel) was bent more than 10° out of shape (Fig. 1). Questionable.
5.1.18	Compatibility	The eyepieces will be compatible with any 53-70-24 [redacted] Zoom Stereoscope (Zoom [redacted] and with the new 53-70-25 Image Rotation Versions of the Stereoscope (Zoom [redacted] only.	Mount on several appropriate Zoom [redacted] Stereoscope Systems.	Two operating components evaluated the eyepieces on different Zoom [redacted] and found no fault except for the locking feature see paragraph 5.2.2(c). Preacceptance and acceptance testing used still other Zoom [redacted] with the same results. Meets requirement.
5.1.19	Operation Manual	Operation manual will be delivered.	Study it and apply the Gunning Fog Index which gives the years of formal education a reader would need to read it with ease and understanding.	Most features are well described. The locking feature description is not up-to-date. There is no warning about possible damage when inserting into the Zoom [redacted] (See paragraph 5.3.4) There

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Acceptance Tests (continued)

ITEM		DESIGN OBJECTIVES SPECIFICATIONS (REQUIREMENTS)	TEST METHOD	RESULTS - CONCLUSION
5.1.19	Operational Manual (continued)			is no discussion of measurement errors that can be introduced by accidential changes in the IPD. A sample paragraph had a fog index of 12.5 years. (8 to 14 is considered good.) Not satisfactory.
5.1.20	Optical Schematic	An optical schematic will be furnished in lieu of optical detail drawings.	Examine	Drawings 537025-001, 537053-001, and 537057-001 satisfy this requirement. Meets requirement.
5.1.21	Drawings	Manufacturing drawings will be provided for mechanical parts and assemblies.	Check	About 40 drawings were furnished. They appear to be adequate except for B537055-128 which does not correspond to the part and 311650-127 which is difficult to read. Essentially meets requirement.

5.2 Operational Evaluation

5.2.1 General

Both IEG and IAS conducted operational evaluations of the Filar Eyepiece set. They gave their findings to ESD/TEB for inclusion in this T&E Report. Their comments included both favorable and unfavorable ones.

5.2.2 Subjective Comments

Below is a collection of comments from the operating components.

(a) The magnification (7X) is satisfactory.

(b) There is negligible distortion of the image and no distracting color is introduced.

(c) The locking screw does not hold the Filar eyepiece firmly in place. The entire eyepiece sometimes turns when the micrometer knob is turned, thus causing an error in the measurement. Image rotation (on the Zoom [redacted] frequently occurs when the Filar eyepiece is turned. 25X1

(d) The fixed scale is satisfactory, its location is good, and its width and density are acceptable. The cross line (of the movable crosshair) should be longer to facilitate alignment with long objects.

(e) The width of the field-of-view and its flatness are impressive.

(f) The torque adjustment (for the micrometer drum) is especially good.

5.3 Engineering Analysis and Evaluation

5.3.1 There is no mechanical stop at one end of the micrometer drum's range. At about 0.17 of a revolution past zero on the scale the drum begins unscrewing from the filar eyepiece.

5.3.2 When the interpupillary distance setting of the Zoom [redacted] is changed the eyepiece tubes rotate slightly. Since they contain pechan prisms the images rotate through twice the angle that the eyepiece tube is rotated. Consequently, the reticle and imagery rotate unequal amounts. 25X

5.3.3 Changing the orientation of the filar measuring axis typically changes the image rotation settings. See also 5.2.2 (c).

5.3.4 When the left eyepiece tube focus adjustment of the Zoom [redacted] is all the way down, the filar eyepieces encounter 1 to 2mm of intereference upon being inserted into that tube. No interference occurs in the normal focus range of the instrument. 25X1

5.3.5 Three out of five observers had great difficulty maintaining parallelism when translating the filar crosshair over a set of parallel lines. The filar eyepiece locking mechanism requires optimum adjustment because overtightening causes the metal spring arm to bear against the eyepiece tube which takes some pressure off of the rubber friction pad. About 25 inch-ounces is the maximum torque obtainable. The operator's hand operates the filar micrometer drum at a lever arm distance of about 2 1/2 inches. Therefore a tangential force of only 10 ounces will override the eyepiece lock under even the best conditions.

5.3.6 When the filar eyepiece is left on the Zoom [redacted] for a long time (from one day to the next) the rubber friction pad sometimes sticks to the eyepiece tube of the Zoom [redacted] Sometimes some of the rubber is left on the Zoom [redacted] when the filar eyepiece is removed leaving a rough surface on the outside of the eyepiece tube. 25X1 25X1 25X1

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